

Space Weather Technical Forecast

Issued on Friday, 16 February 2024 at 13:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Isolated M-flares likely and a chance of X-flares. Likely chance for S1/Minor Solar radiation storms Day 1.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High, with an X2.5 flare peaking at 16/0653 UTC and emanating from AR3576 which is approaching the southwest limb. A couple of M-flares have also come from this same region. AR3576 is one of ten regions on the visible disc. AR3582 is fading and simplifying, while AR3583 has increased in complexity, with the development of intermediate spots, although this has not resulted in increased activity. Several benign or stable regions are dotted around the disc, with a couple of new regions appearing. These will be monitored for further developments.

A couple of possible Earth-directed CMEs were observed in the past 24hrs. The first as a result of a filament liftoff in the centre-north disc, and a second in association with the X2.5 flare from the southwest limb. Both of these are awaiting further coronagraph imagery to be fully analysed.

Solar Wind / Geomagnetic Activity: Solar winds as observed L1 have remained fairly steady at slightly elevated levels, with observations at ACE suggesting speeds of just above 400 km/s. Density has generally been at Average to Below Average levels. The total interplanetary magnetic field (IMF), Bt, has varied between 4 and 9 nT. The north-south component, Bz, varied weakly throughout, between -4 and +6 nT. Phi angle was predominantly positive (away from the Sun) but became negative (towards the Sun) from 16/1031 UTC. Geomagnetic activity was Quiet (Kp 0 to 1).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux has been below the S1/Minor Storm threshold throughout, but has seen a recent rise in response to the X2.5 flare mentioned above, around 4 to 5 pfu. The proton flux has currently plateaued, and is expected to slowly begin to decline back to background levels. Electron flux (greater than 2MeV) has been at background, with electron fluence well below the Active (1e8 integrated pfu) threshold. The observed fluence at 15/0000UTC was 1.48e6 pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected with a likelihood of M-class flares and a chance of X-class flaring.

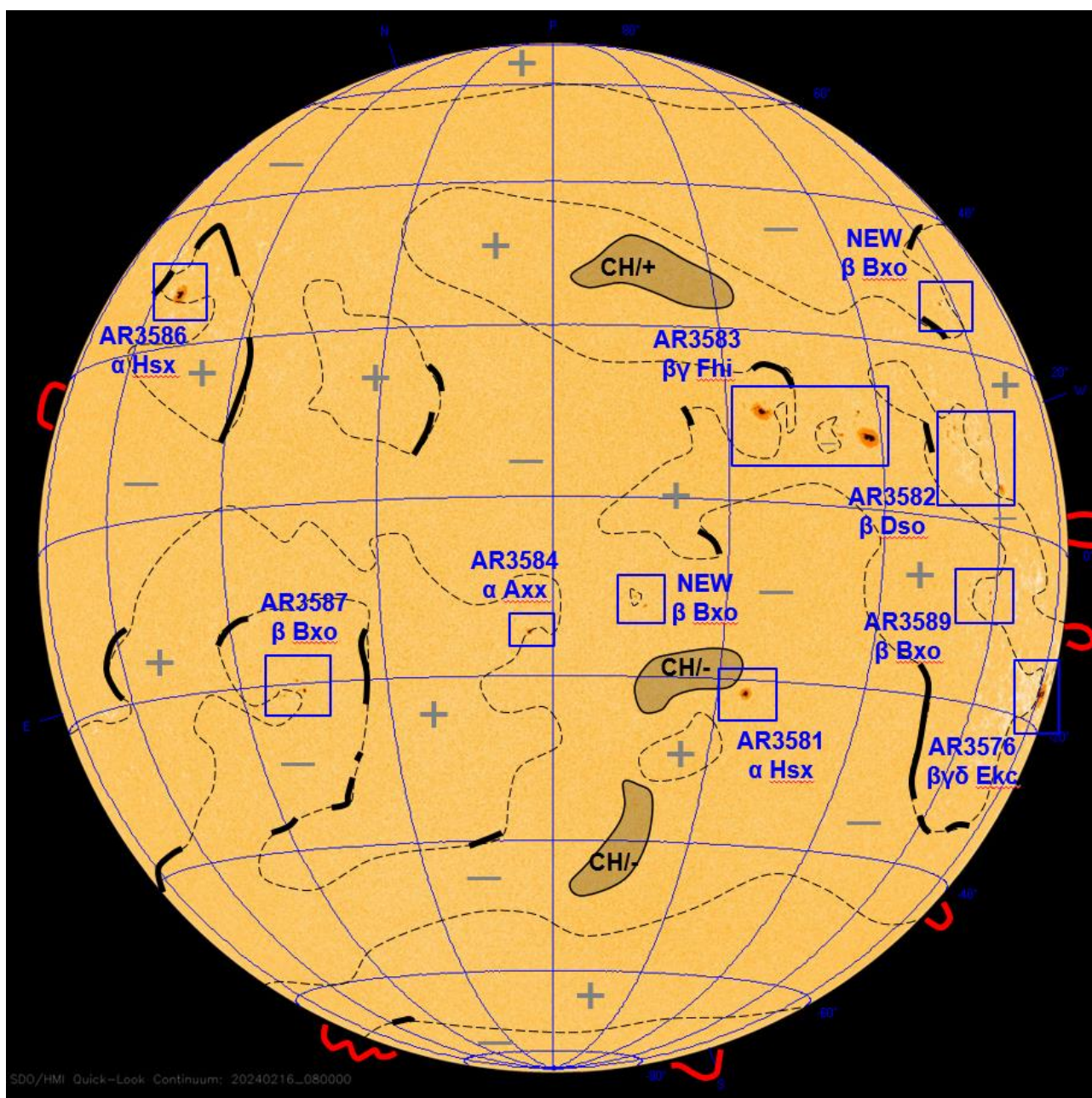
Solar Wind / Geomagnetic Activity: Two possible Earth-directed CMEs occurred, with full analysis awaiting more complete coronagraph imagery. An early estimate is for a glancing blow CME(s) on Day 3 (18 Feb). Solar winds are at slightly elevated levels, and are expected to decline towards ambient levels through the coming days. No coronal hole enhancements are expected, with all possible sources appearing weak. Quiet geomagnetic activity is expected to

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continue at first, with Day 3 possibly seeing a rise to Active-Minor Storm levels if any CMEs arrive.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux is at elevated levels currently in response to the X2.5 flare, but remain below the warning threshold. They are forecast to slowly start to decline back towards background levels in the absence of any further sources of radiation storms, with AR3576 still presenting a limited risk. High energy electron flux (greater than 2MeV) is expected to remain at background. The associated 24-hour electron fluence is expected to stay below the Active threshold.

Figure 1. Solar Analysis Valid 16/0800 UTC.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

Two possible Earth-directed CMEs have occurred in the past 24 hours. The first was as a result of a large filament liftoff from the centre north disc. The second CME was in association with the X2.5 flare from the AR3576 sunspot region. A large amount of ejecta is visible in available imagery emanating from both these regions. The large appearance of the X2.5 CME suggests that some impact may be possible at Earth, but maybe only a glancing blow. Both CMEs are awaiting more complete coronagraph imagery to be able to to be analysed fully. A rough estimate for these CME arrival looks to be at some point on Day 3 (18 Feb).

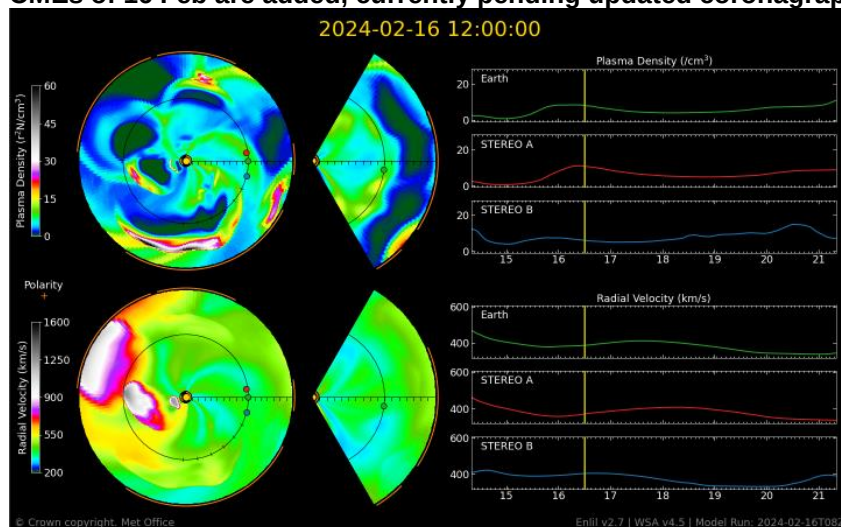
A CME was observed off the northeastern limb late 15 Feb, but was deemed to be missing behind Earth. Another CME was observed coming off the southeast disc shortly after, but was analysed to be far-sided and therefore having no Earth impact also.

No significant coronal holes are visible on the Earth-facing disc, with three weak coronal holes all weak and relatively small. Based on this and in the absence of any CME arrivals, solar wind speeds are expected to slowly decrease from slightly elevated to background levels.

Mainly Quiet geomagnetic activity expected through the start of the period, with a chance for G1 Minor Storm levels on Day 3 with the possible CME arrival(s).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	5	15	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: MOSWOC Enlil currently showing no Earth-directed CMEs. This may change when the two CMEs of 16 Feb are added, currently pending updated coronagraph imagery.



Radio Blackouts - X-Ray Flares:

Activity has been High, with an X2.5 peaking at 16/0653 UTC from the AR3576 sunspot region just rotating around the southwestern limb. Two M-class flares from the same region were also observed.

There are currently 10 sunspots on the visible disc. AR3576 is becoming increasingly difficult to analyse as it rotates over the southwestern limb, but it likely remains a large, magnetically complex region. AR3583 has developed intermediate spots and has spread in length, with some increased magnetic complexity. AR3582 appears to have simplified with penumbra on trailing spots fading. AR3585 and AR3588 have both faded to plage. Two new regions have recently appeared, one near centre disc and the other in the far northwest, both currently small and simple. The remaining regions are a mixture of weakening and simple regions, with no significant developments.

Due to AR3582 fading and AR3576 rotating around the southwestern limb, a declining trend in flare risk is forecast through the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	50
Very Active	R3 to R5 X Class	Yes	25	15	10	10

Figure 3: GOES16/18 X-ray flux



Solar Radiation Storms - (High Energy Protons):

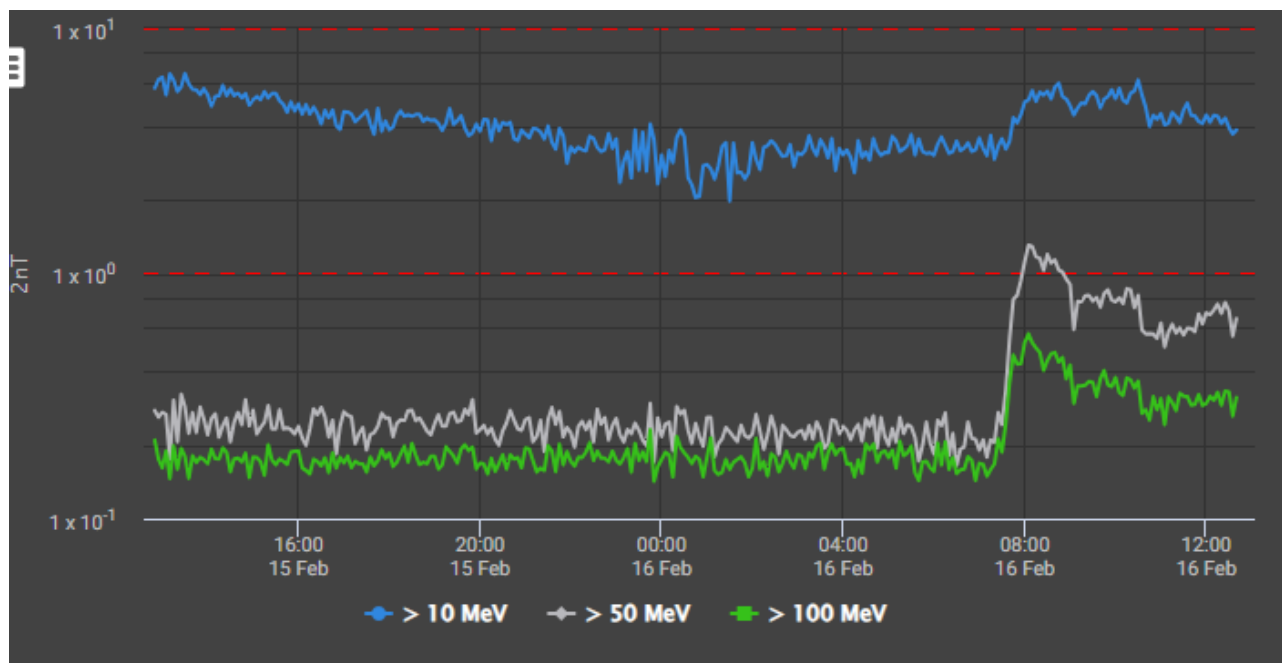
GOES 18 high energy (greater than 10MeV) protons rose in response to the X2.5 flare that originated from AR3576. Values rose to elevated levels but stayed below the warning threshold, and have since plateaued. Proton flux is expected to start slowly declining through the period in the absence of further significant flare activity.

The risk of further enhancements will mostly likely be as a result of AR3576, or AR3583, which is becoming more complex. Both these regions are in the western hemisphere which is prime location for an Earth-connection from any proton rich flare eruption. The solar radiation storm risk declines later in the period as AR3576 rotates further off the visible disc.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	70	30	15	10
Very Active	$\geq \text{S3}$ *	No	1	1	1	1

* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

Figure 4: GOES18 Proton flux



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) at GOES16 is expected to remain at background level, with no notable immediate inputs into the radiation belts. Any CME arrivals on Day 3 may see some charging of the electron belts, with a possible response beyond that.

24-hour fluence values are expected to continue to track at background levels, based on the lack of inputs into the radiation belts.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	1	5
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1